Surface Diffuser - Direct View Screen

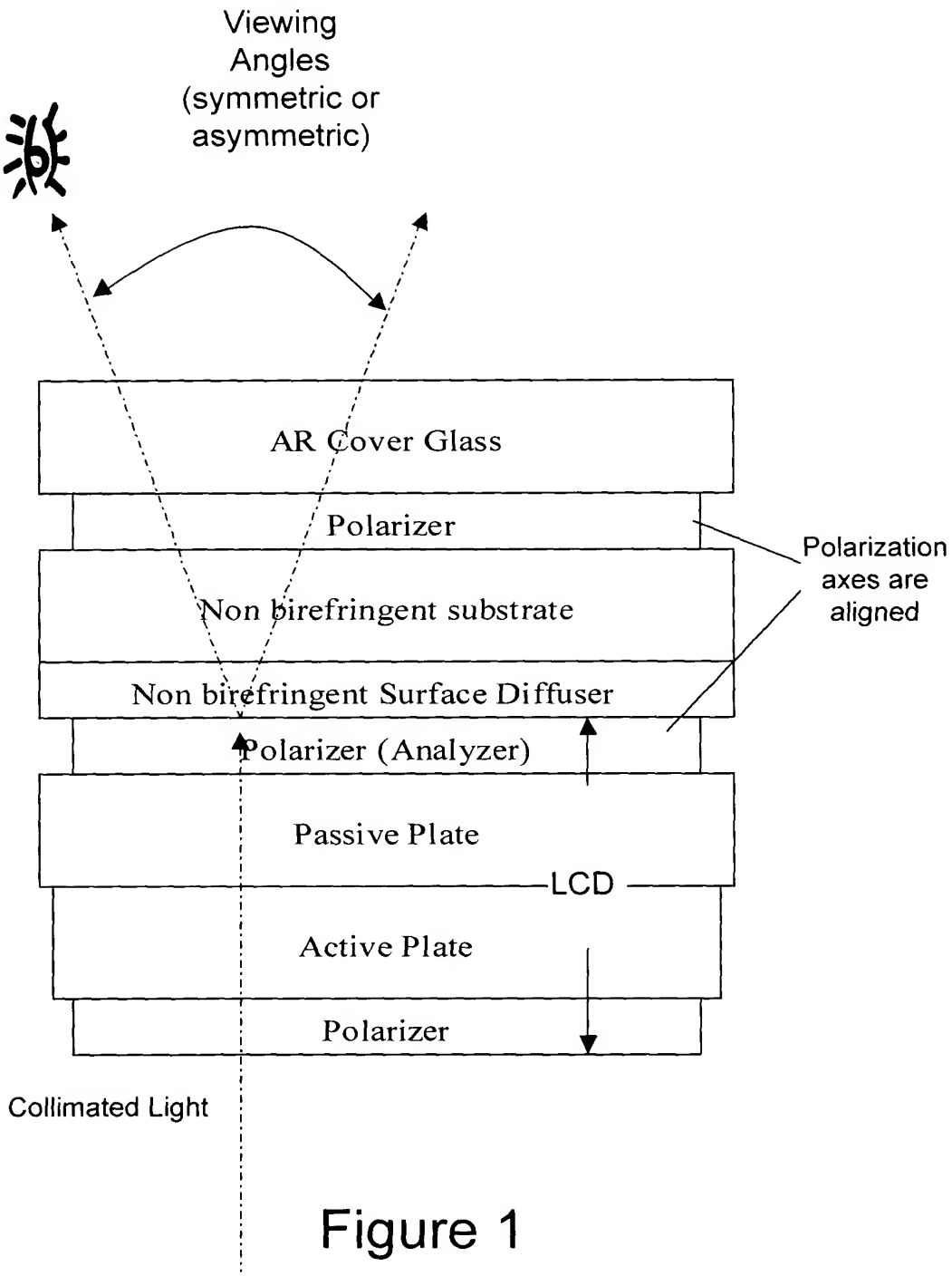


Figure 1

Backlight Collimation

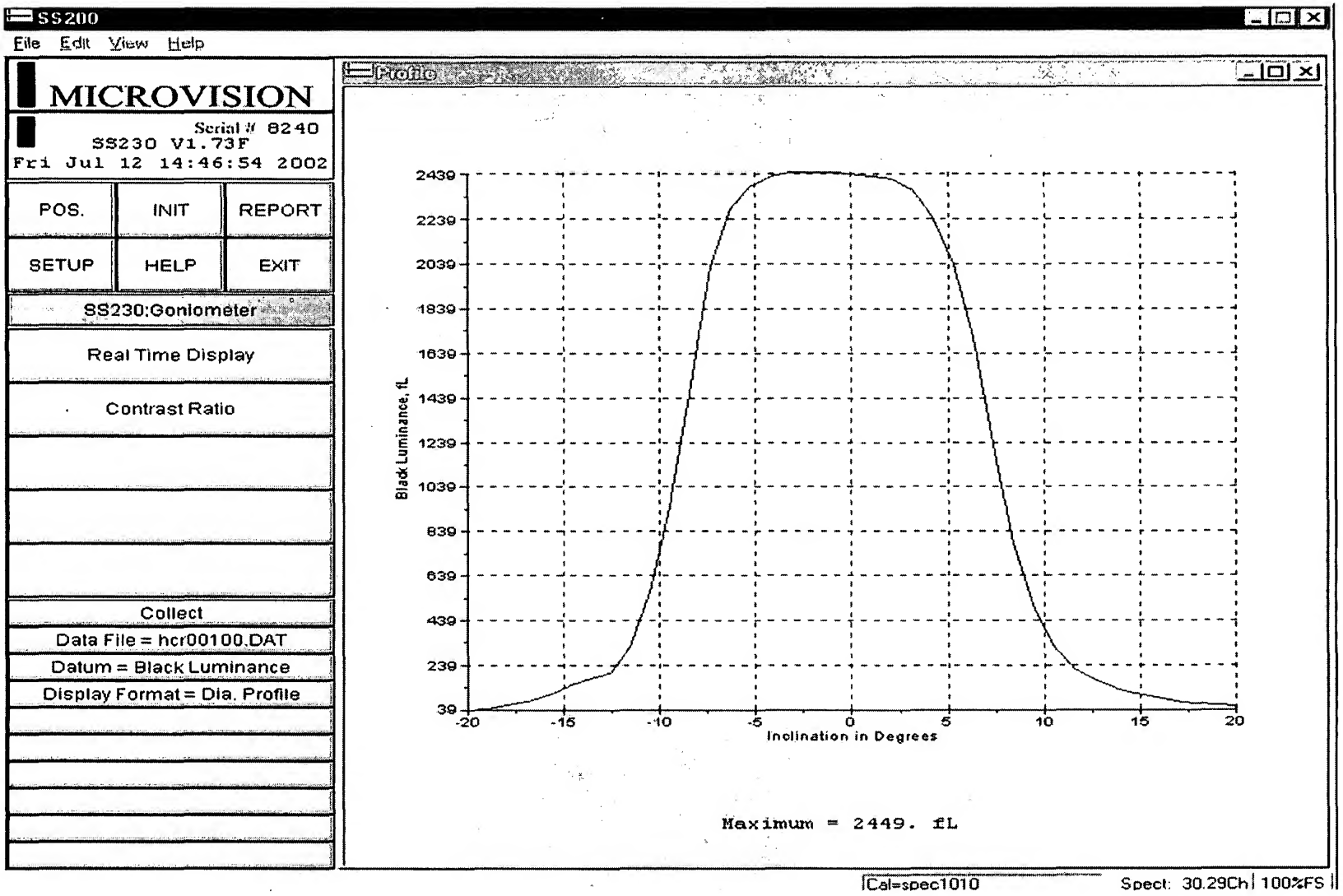


Figure 2

Viewing Screen for Direct View LCDs

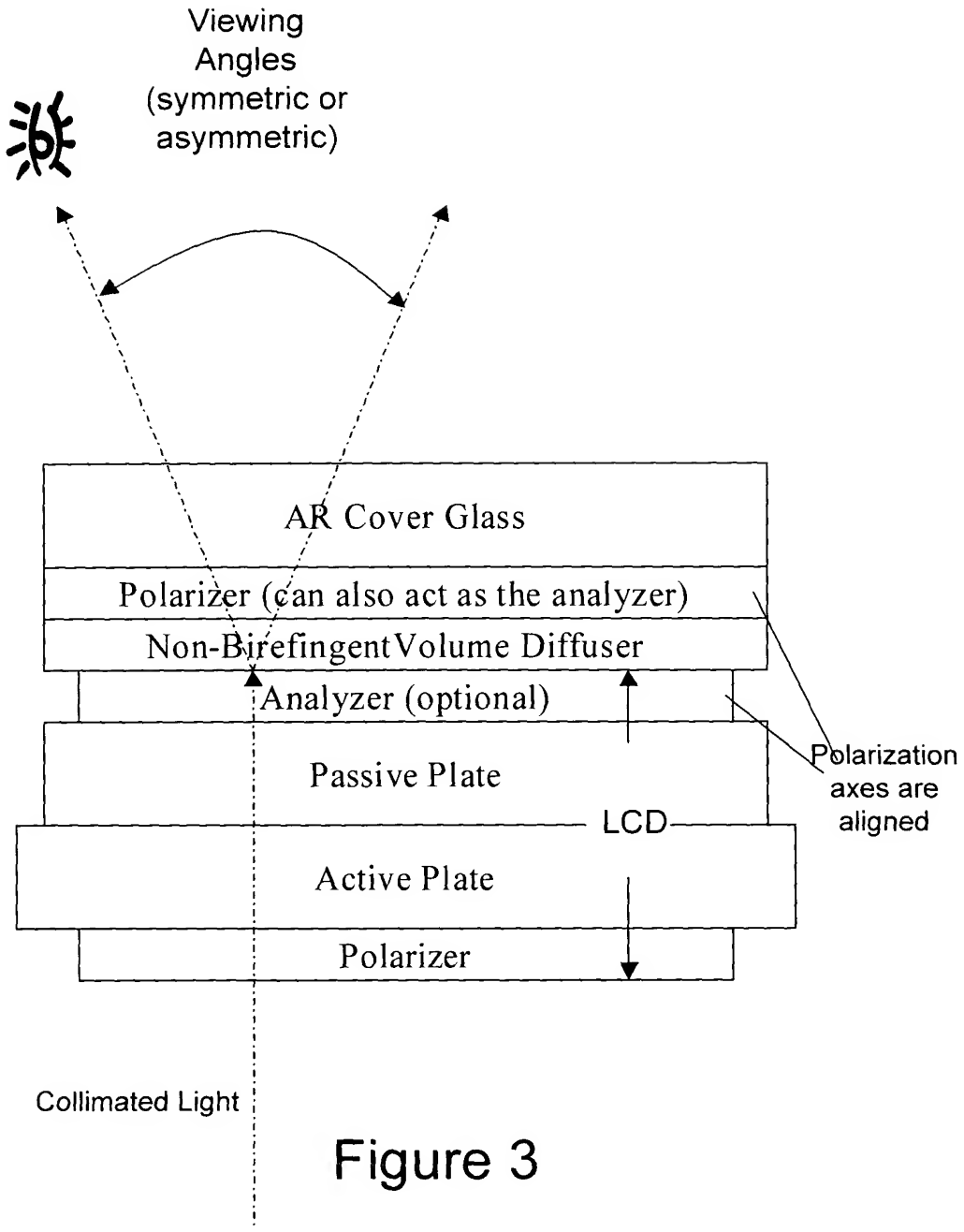


Figure 3

Volume Diffuser - Rear Projection Screen

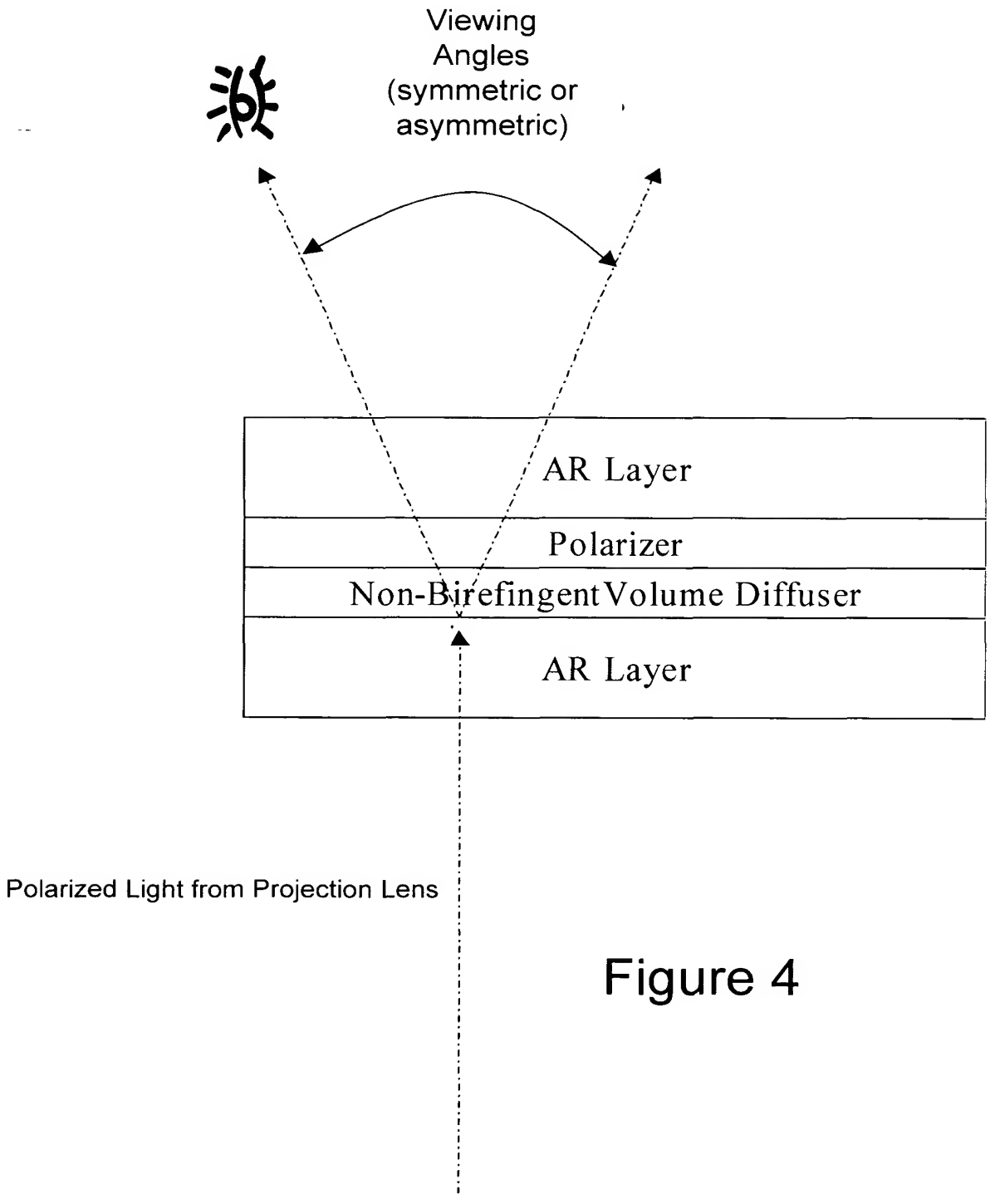


Figure 4

Front Projection Screen

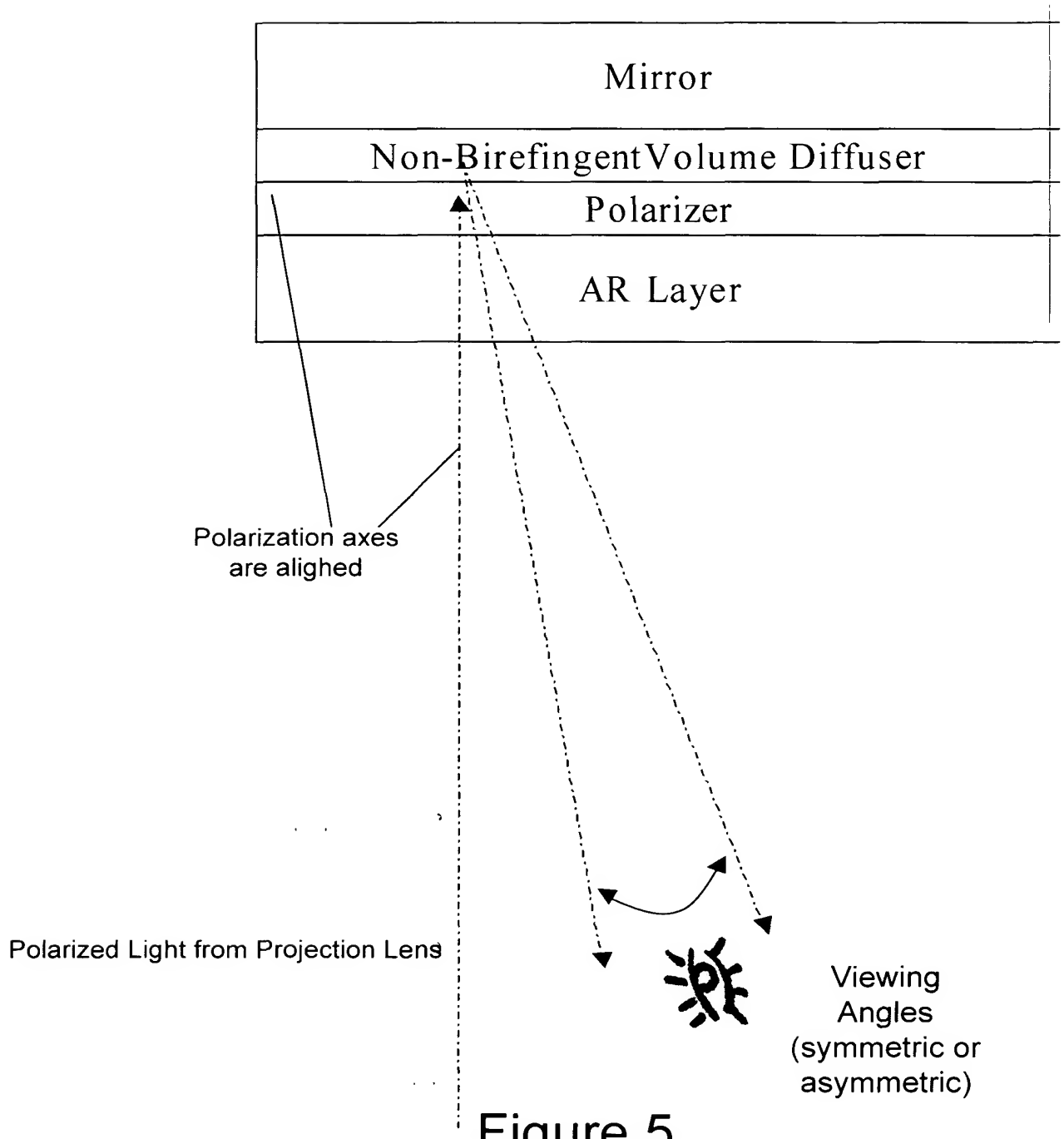


Figure 5

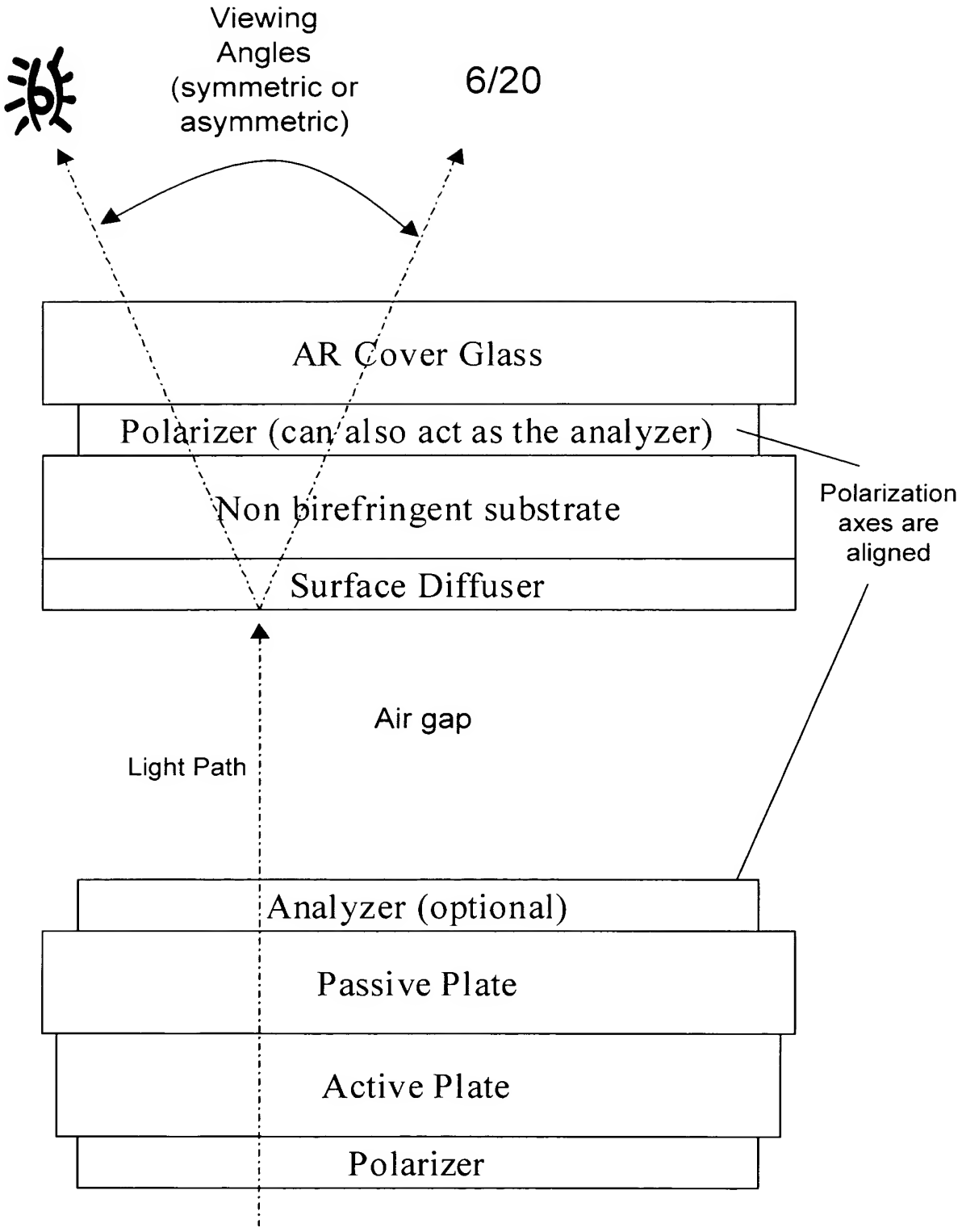

Viewing
Angles
(symmetric or
asymmetric)
AR Cover Glass
Polarizer (can also act as the analyzer)
Non birefringent substrate
Surface Diffuser
Polarization
axes are
aligned
Air gap
Light Path
Analyzer (optional)
Passive Plate
Active Plate
Polarizer

Figure 6

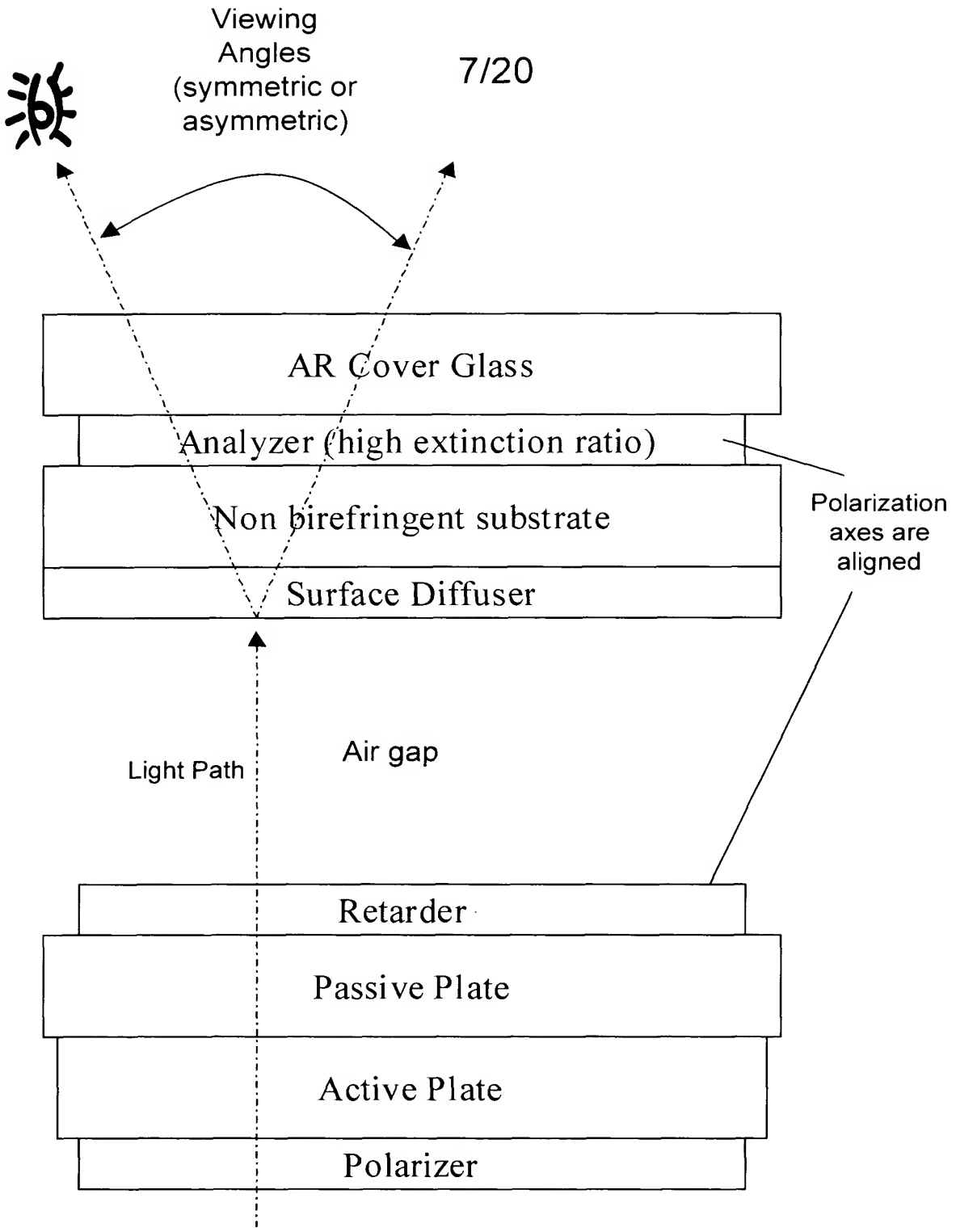

Viewing
Angles
(symmetric or
asymmetric)
AR Cover Glass
Analyzer (high extinction ratio)
Non birefringent substrate
Surface Diffuser
Polarization
axes are
aligned
Light Path
Air gap
Retarder
Passive Plate
Active Plate
Polarizer

Figure 7

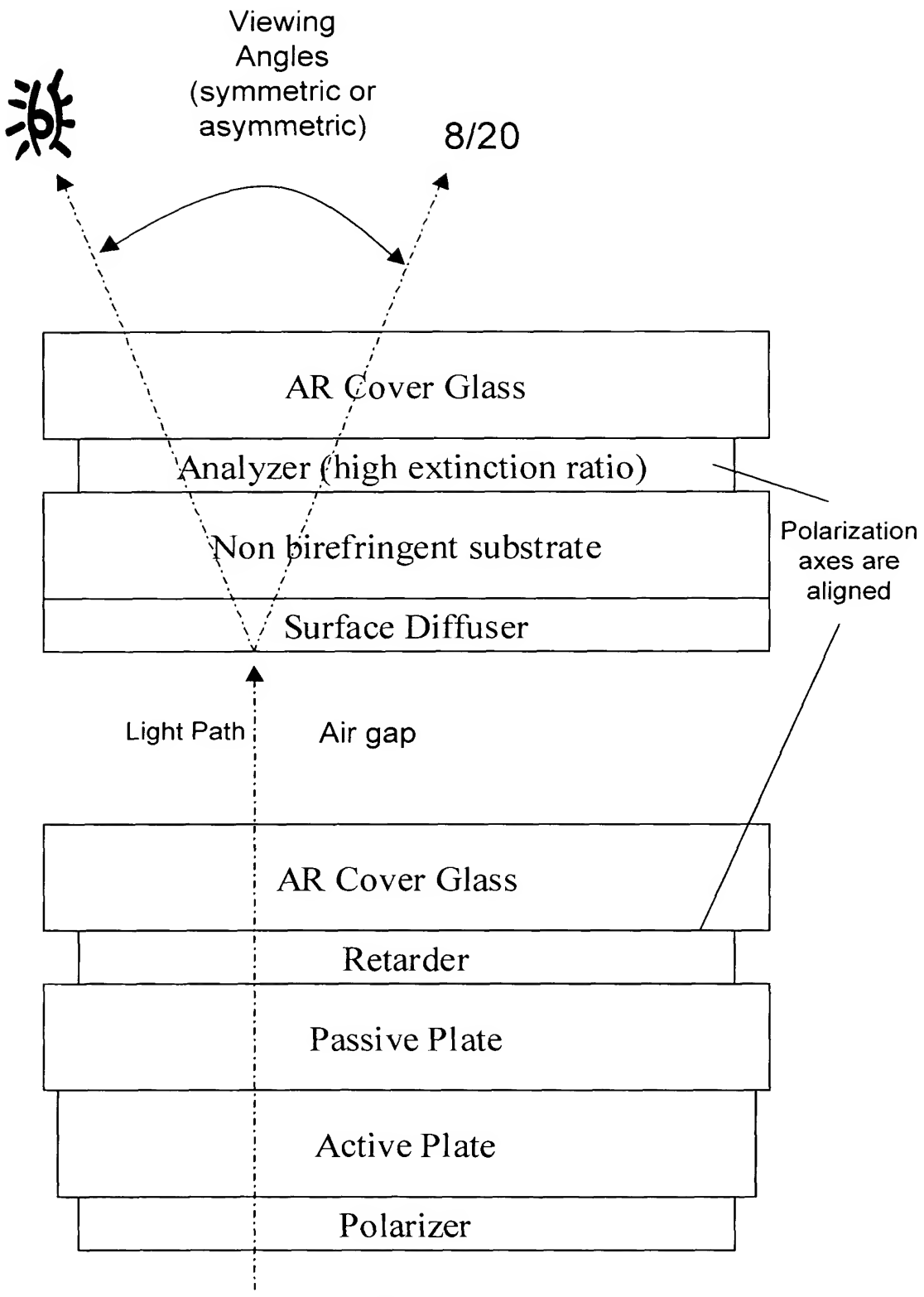
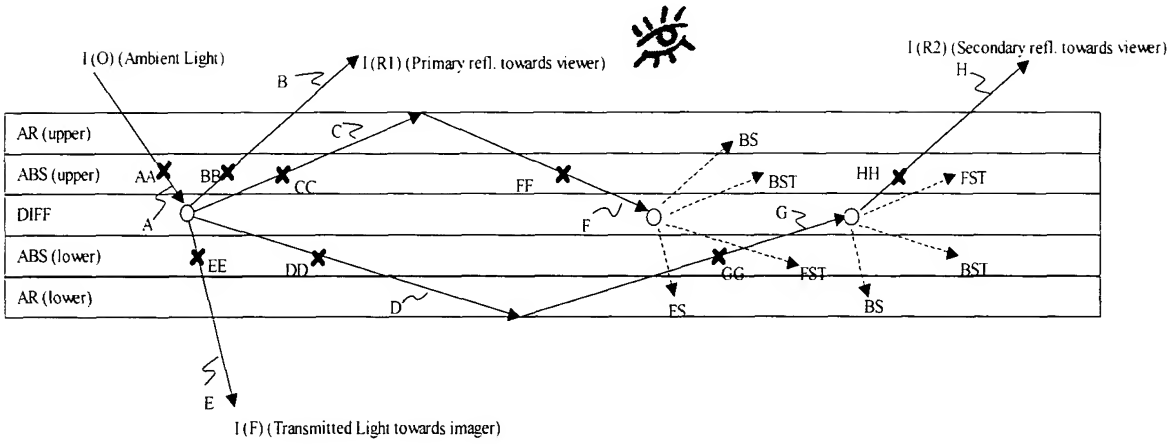

Viewing
Angles
(symmetric or
asymmetric)
AR Cover Glass
Analyzer (high extinction ratio)
Non birefringent substrate
Surface Diffuser
Polarization
axes are
aligned
Light Path
Air gap
AR Cover Glass
Retarder
Passive Plate
Active Plate
Polarizer

Figure 8

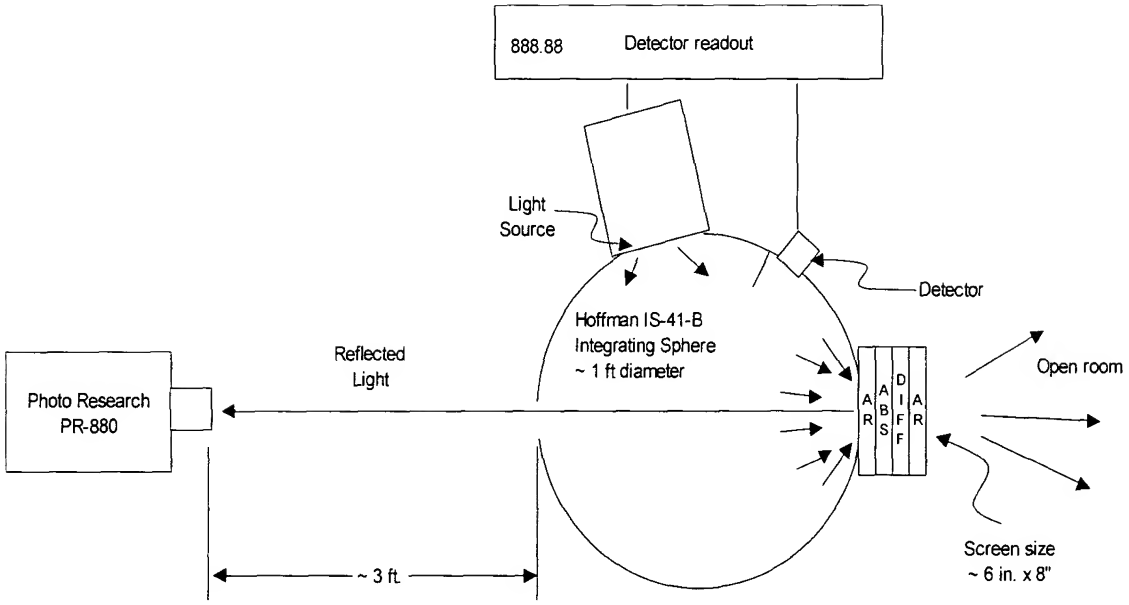
1st Order Screen Reflection Model



Key :			
BS	Back scatter component		
BST	Back scatter component resulting in TIR		
FS	Forward scatter component		
FST	Forward scatter component resulting in TIR		
AR	Antireflection layer		
ABS	Absorbing layer		
✘	Denotes absorption		
DIFF	Diffuser		
I(O)	Ambient light incident on screen		
I(R1)	Primary reflection component		
I(R2)	Secondary reflection component		
I(F)	Ambient light scattered towards the image source		

Figure 9

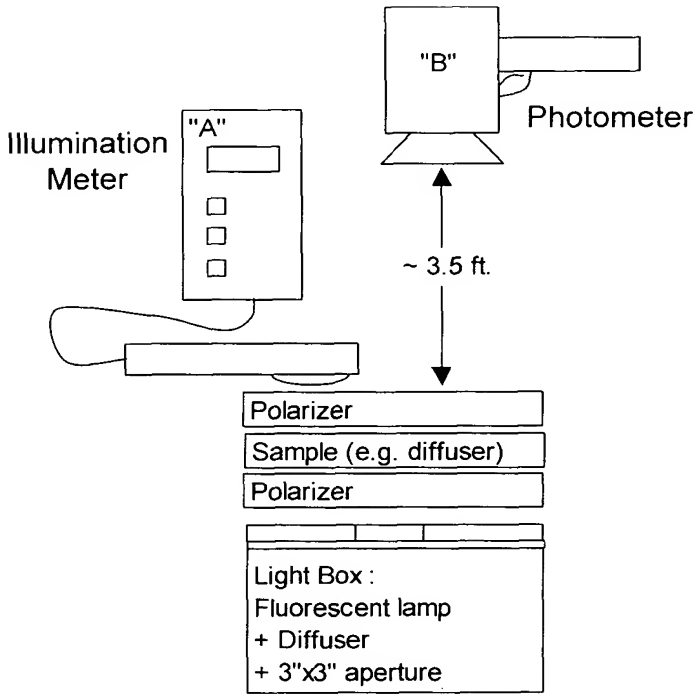
Screen Reflection Measurements



Measured Data			Calculated			
	Sphere Detector	PR-880	Diffuse Reflectance			
Configuration	I_d	L_o	$R_{(d,0)}$			
DIFF	5,245	1,004	19.1%	(1)		
AR/DIFF/AR	5,009	458.8	9.2%	(1)		
AR/ABS(POL)/DIFF/AR	5,015	79.50	1.6%	(1)		
AR/ABS(POL)/DIFF/ABS(POL)/AR	5,027	48.87	1.0%	(1)		
Beaded Screen	5,018	64.90	1.3%	(1), (2)		
(1) These measurements only consider the reflection component normal to the screen under diffuse illumination						
(2) Commercially available screen w/ black matrix and AR-coated glass substrate						
Key :						
Diff	Diffuser					
AR	Glass substrate w/ AR coating on the surface that will interface with air in the multilayer configuration					
ABS(POL)	Absorber - Linear Polarizer in this configuration					
Multilayer configurations (those above with "/" between layers) comprise index-matched substrates						

Figure 10

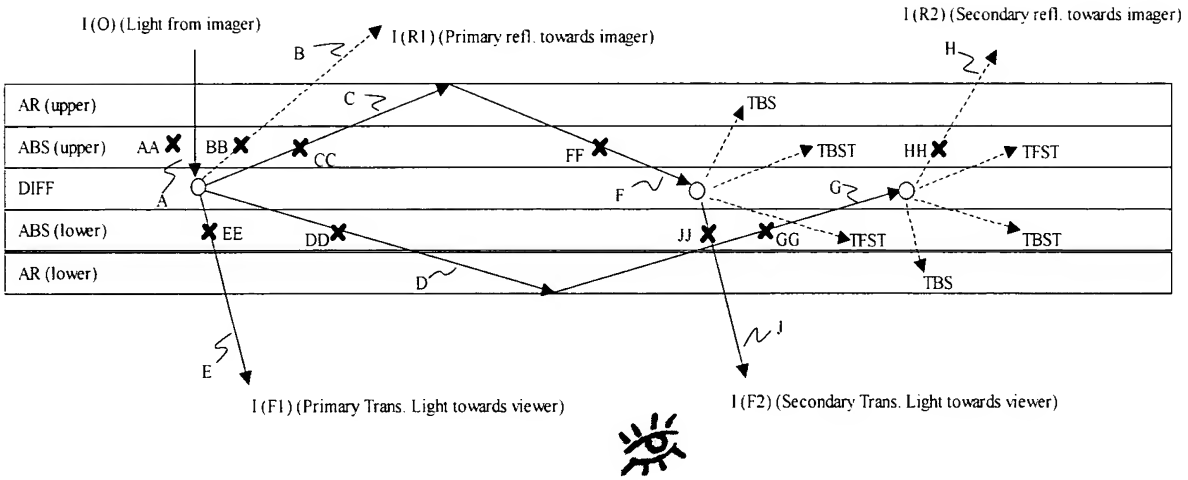
Screen Transmittance Measurements



Measured Data			
Measured w/ INS DX200 Illumination Meter ("A")			
	Original diffuser film (1)	Ruggedized diffuser (2)	No diffuser
Parallel linear polarizers	1,612.0	1,742.0	2,520.0
Crossed linear polarizers	301.0	203.0	92.9
Discrimination ratio	5.4	8.6	27.1
Measured w/ Minolta handheld photometer ("B")			
	Original diffuser film (1)	Ruggedized diffuser (2)	No diffuser
Parallel linear polarizers	2,380.0	2,590.0	3,300.0
Crossed linear polarizers	196.0	108.0	1.6
Discrimination ratio	12.1	24.0	2,062.5
(1) Same as "DIFF" in Fig. 10			
(2) Same as AR/DIFF/AR in Fig. 10			

Figure 11

1st Order Screen Transmittance Model



TBS	TIR light that is back-scattered
TBST	TIR light that is back-scattered into more TIR light
TFS	TIR light that is forward-scattered
TFST	TIR light that is forward-scattered into more TIR light
AR	Antireflection layer
ABS	Absorbing layer
✘	Denotes absorption
DIFF	Diffuser
I(O)	Ambient light incident on screen
I(R1)	Primary reflection component
I(R2)	Secondary reflection component
I(F)	Ambient light scattered towards the image source

Figure 12

High Ambient Contrast Calculations

$$CR_{HA} = \frac{(Y + \%D * D + \%S * S)}{\left(\frac{Y}{CR_{DA}} + \%D * D + \%S * S\right)}$$

Diffuse ambient	D	45 fc 484 lux	D	45 fc 484 lux	D	45 fc 484 lux
Specular reflectance	%S	1.0%	%S	1.0%	%S	1.0%
Specular ambient	S	100 fL	S	100 fL	S	100 fL
Dark Ambient Contrast Ratio	CR_{DA}	300	CR_{DA}	300	CR_{DA}	300
Luminance	Y	100 fL	Y	10 fL	Y	1 fL

Diffuse Reflectance %D	High Ambient Contrast Ratio CR_{HA}	Diffuse Reflectance %D	High Ambient Contrast Ratio CR_{HA}	Diffuse Reflectance %D	High Ambient Contrast Ratio CR_{HA}
0.6%	63.2	0.6%	8.6	0.6%	1.8
0.8%	59.9	0.8%	8.2	0.8%	1.7
1.0%	56.9	1.0%	7.7	1.0%	1.7
1.2%	54.2	1.2%	7.3	1.2%	1.6
1.4%	51.8	1.4%	7.0	1.4%	1.6
1.6%	49.5	1.6%	6.7	1.6%	1.6
1.8%	47.5	1.8%	6.4	1.8%	1.5
2.0%	45.6	2.0%	6.2	2.0%	1.5
3.0%	38.1	3.0%	5.2	3.0%	1.4
4.0%	32.8	4.0%	4.5	4.0%	1.4
5.0%	28.8	5.0%	4.0	5.0%	1.3
6.0%	25.7	6.0%	3.7	6.0%	1.3

Room ambient lighting

Movie Theatre with emergency lights on approx. 50-80 LUX
Typical office theatrette 120-150 LUX
Ballroom 150-200 LUX (dimmed for presentations)
Training room dimmed 200-250 LUX
Training room full light 350-450 LUX
Source : http://www.dvmg.com.au/iti-f1.html

Figure 13

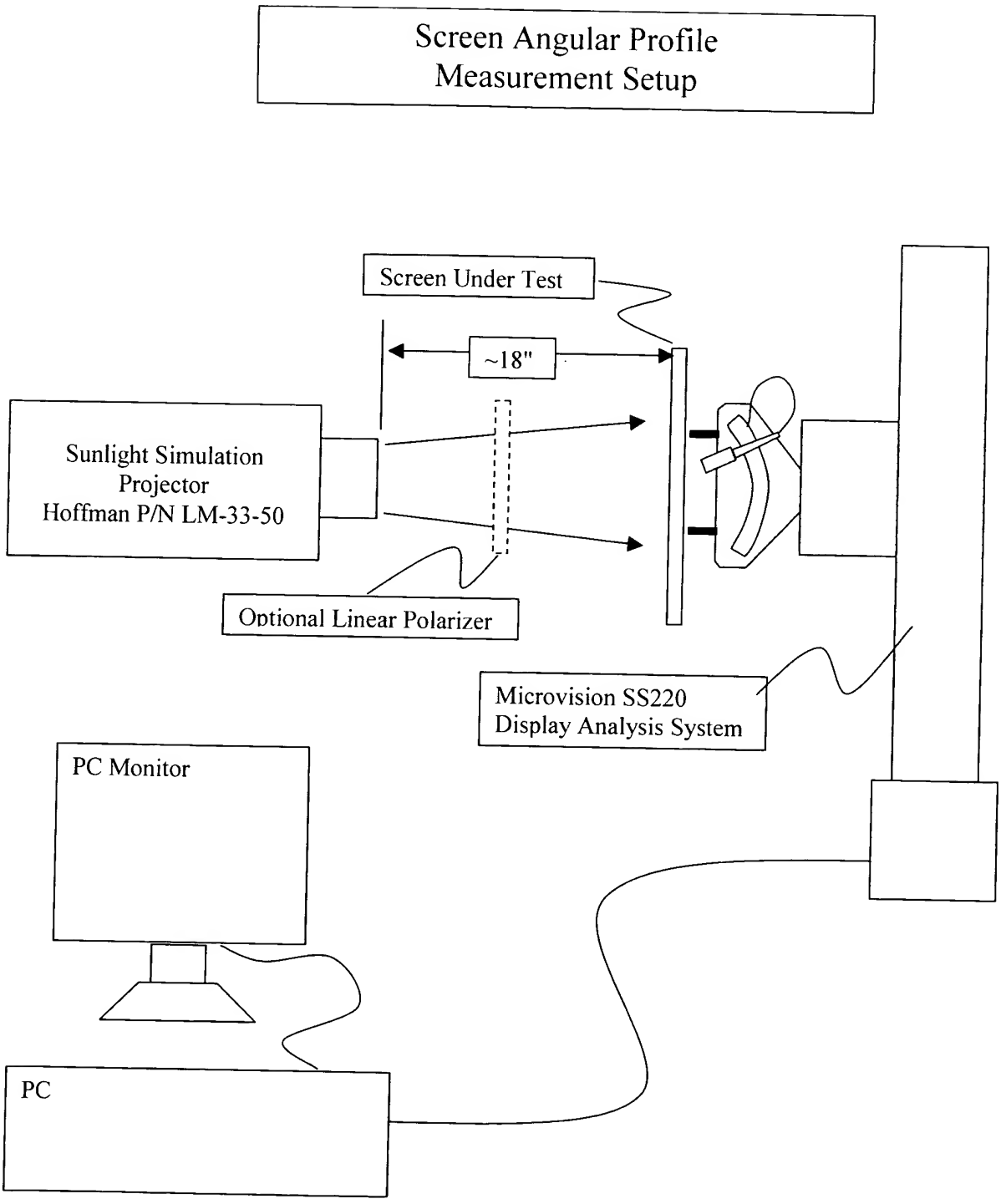

Screen Angular Profile
Measurement Setup
Screen Under Test
~18"
Sunlight Simulation
Projector
Hoffman P/N LM-33-50
Optional Linear Polarizer
Microvision SS220
Display Analysis System
PC Monitor
PC

Figure 14

Screen Measurement Comparisons
with Unpolarized Light Input

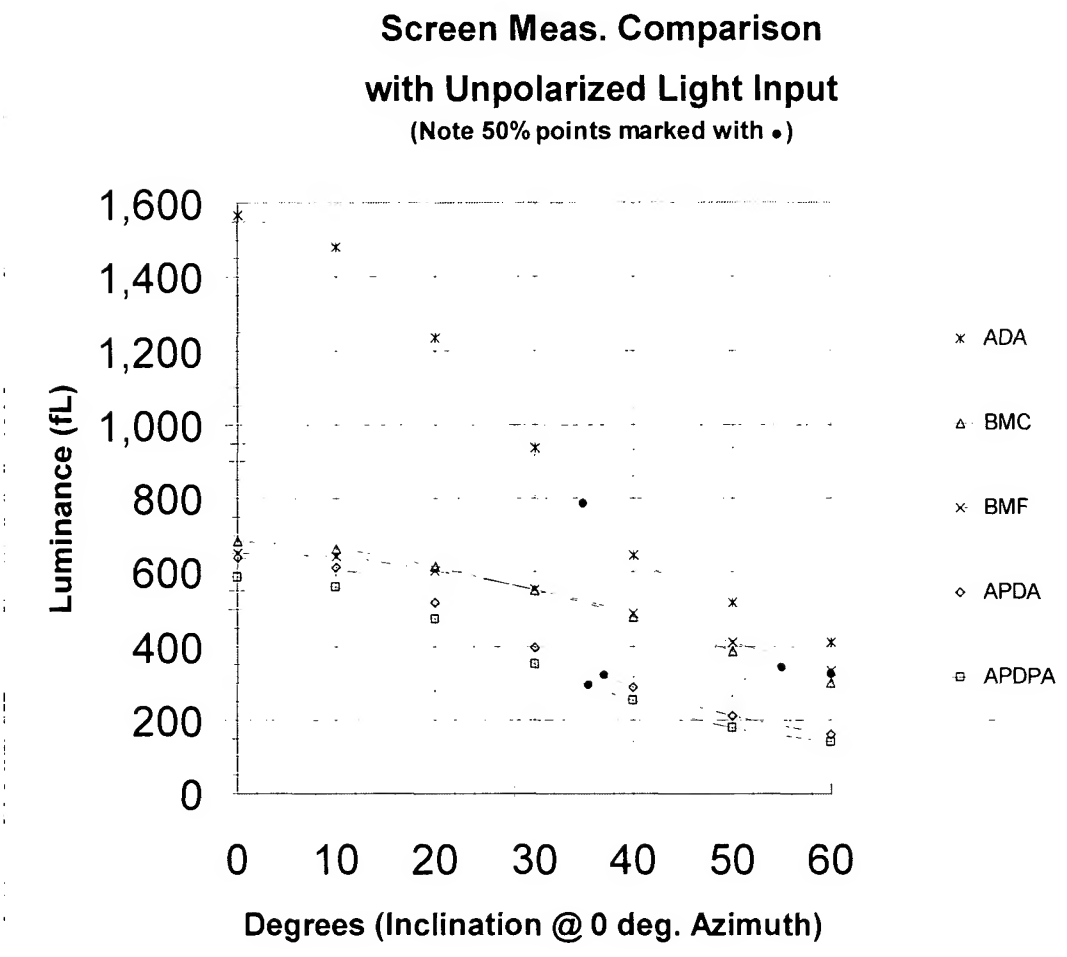


Figure 15

Screen Measurement Comparisons
with Polarized Light Input

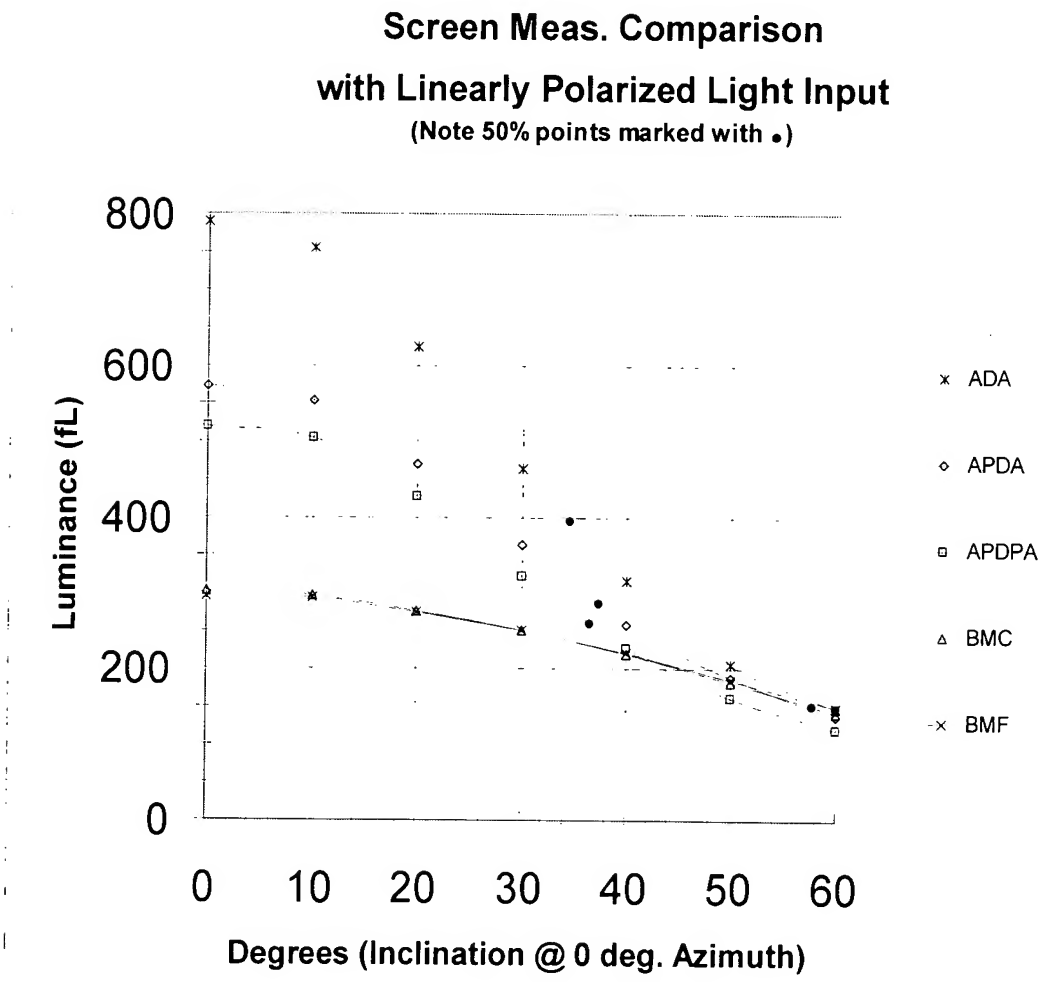


Figure 16

Polar Plots of the Measurements Shown in Fig's 8 & 9

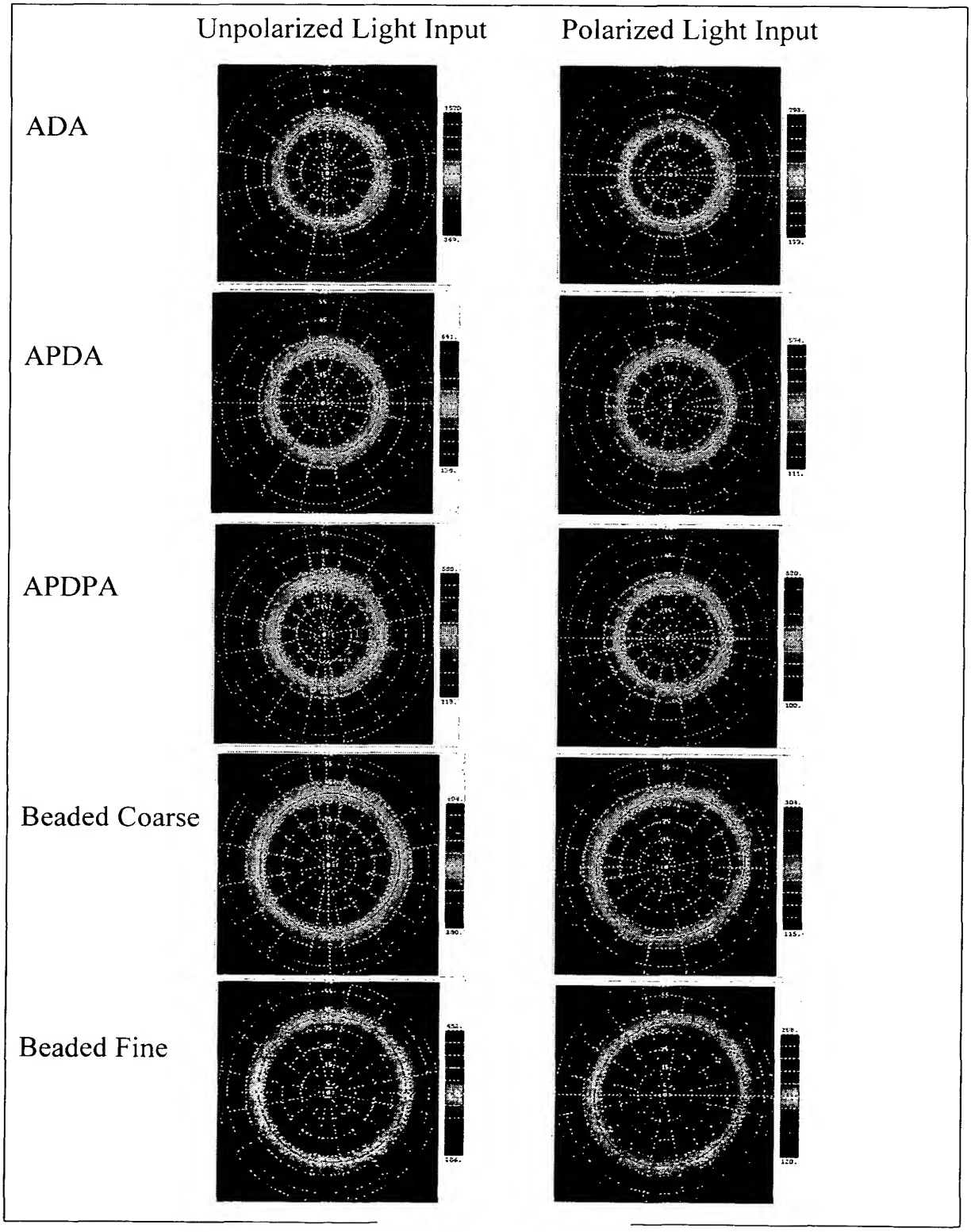


Figure 17

An Example of Retroreflections
In a Viewing Environment

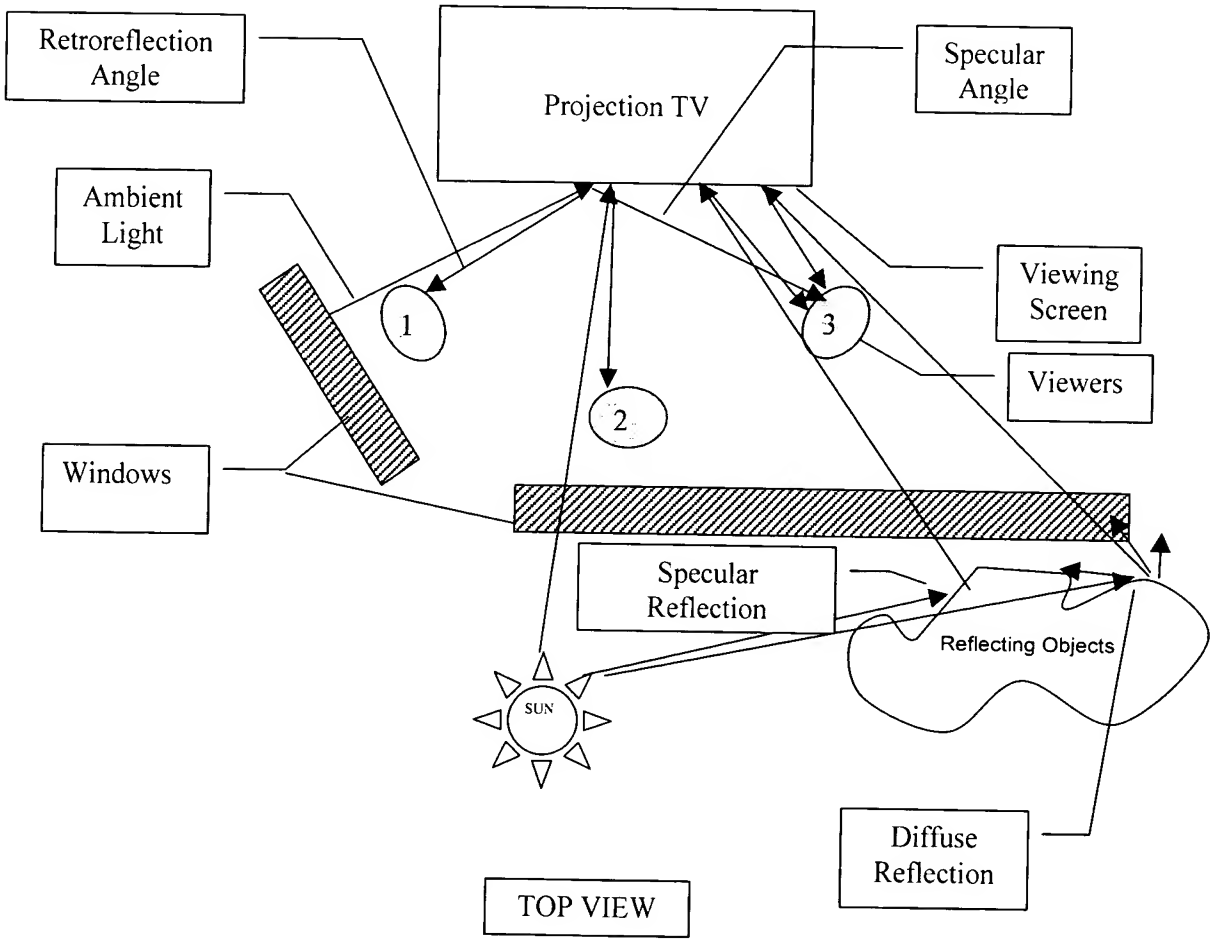


Figure 18

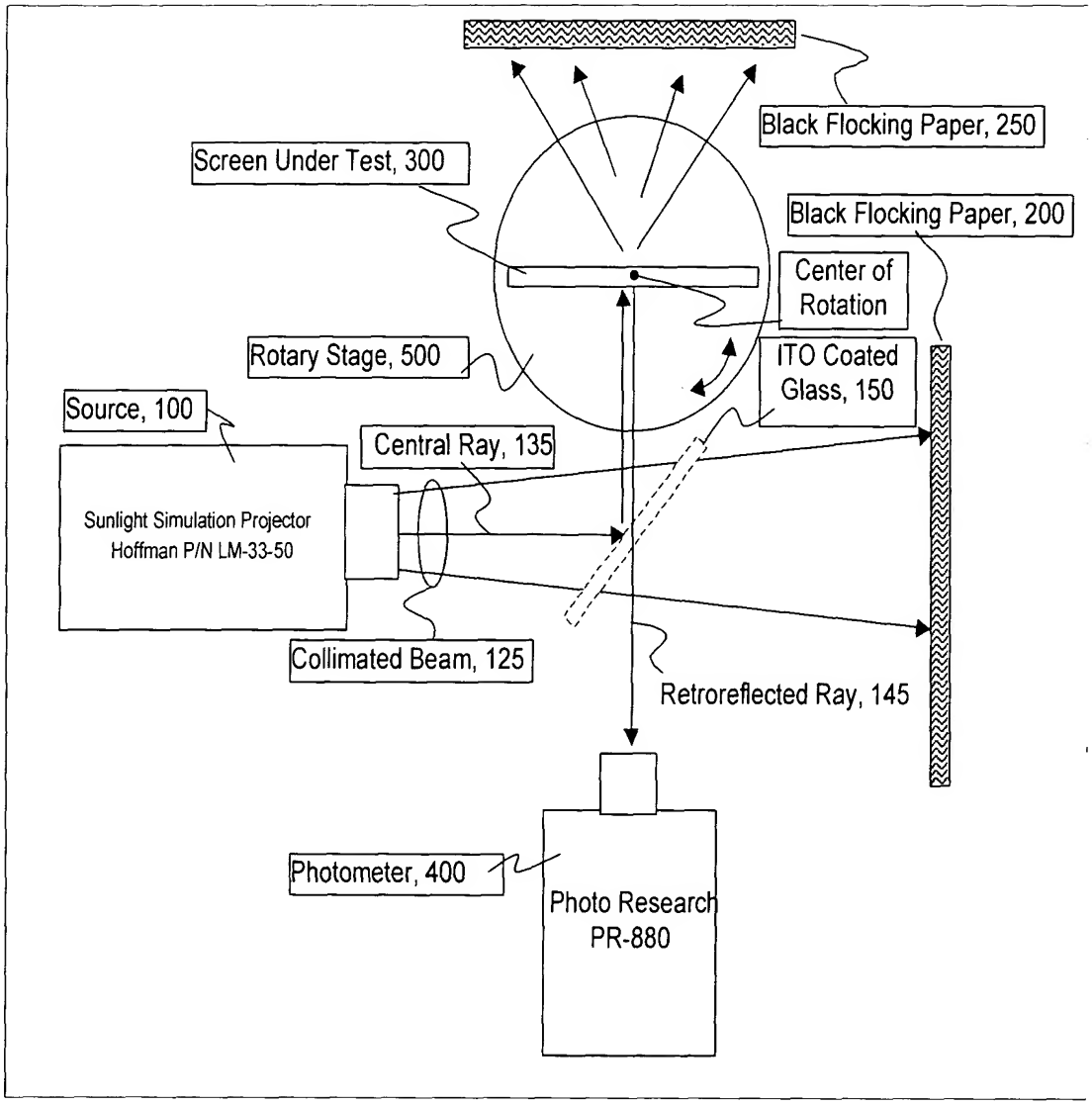

Black Flocking Paper, 250
Screen Under Test, 300
Black Flocking Paper, 200
Center of Rotation
Rotary Stage, 500
ITO Coated Glass, 150
Source, 100
Central Ray, 135
Sunlight Simulation Projector
Hoffman P/N LM-33-50
Collimated Beam, 125
Retroreflected Ray, 145
Photometer, 400
Photo Research
PR-880

Figure 19

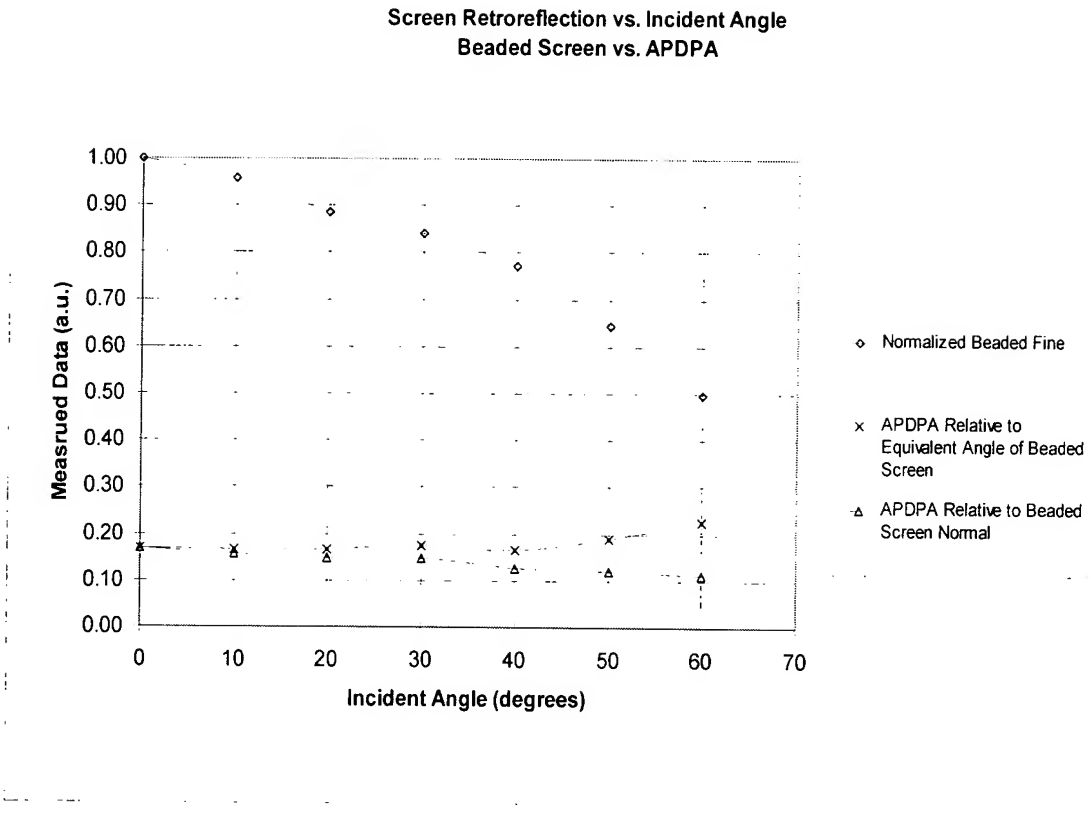

Screen Retroreflection vs. Incident Angle
Beaded Screen vs. APDPA
Measrued Data (a.u.)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
0
10
20
30
40
50
60
70
Incident Angle (degrees)
Normalized Beaded Fine
APDPA Relative to Equivalent Angle of Beaded Screen
APDPA Relative to Beaded Screen Normal

Figure 20